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Title: Counting Room Equipment

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Counting Room Equipment

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Module 2.19

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Agenda

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- **Objectives:**
- **2.19.01: Features and specifications (F&S) of commonly used laboratory counters and scalers**
- **2.19.02: F&S of commonly used laboratory low background automatic counting systems**
- **2.19.03 F&S of commonly used laboratory gamma/alpha spectroscopy systems**

Introduction: Class discussion

- What sort of samples and types of measurements lend themselves to a counting lab ?
- What are the advantages or benefits of measurements in a counting lab relative to field measurements ?
- How are counting lab results used by the RCT ?

Introduction:

- **Features and specifications in common to the various types of laboratory counting equipment to be discussed include:**
  - detector type, shielding and entrance window properties
  - types of radiation detected and measured
  - basic principle of operation and typical user-adjustable controls
  - calibration and source checking procedures
  - operating procedures or protocols

Introduction:

- **Three broad categories of counting room instrumentation:**
  - all of which typically use shielding to reduce background count rates
  - and background subtraction to yield net count rates
  - instrumentation operated manually and/or automatically
  - variety of detectors used depending on application
  - most common samples are swipes and air filters

1) Single channel scaler or gross counting systems

2) Dual channel scaler or gross counting systems

- Utilizing pulse height discrimination (e.g. alpha/beta counting)
- But isotope identification is not possible

3) Multichannel counting systems

- Use spectroscopy to yield isotope identification and apply isotope-specific factors to convert count rates to dpm values.

Introduction:

- **Detector shielding**
  - Gamma detectors most often shielded using lead
    - Preferably pre-World war II – why ?
  - Betas best shielded by low Z materials such as Al or plastic – why ?
    - But beta detectors are sensitive to gamma background (see above)
  - Alphas easily shielded and detector housing more than sufficient
    - Pulse height also usually much larger than gamma or beta interference.
    - But operators must be aware of self-shielding

Introduction:

- **Detector entrance windows**

  – Gamma detectors can have relative thick entrance windows
  - Usually only a concern if low energy gammas are of interest
  - Be windows offer the least attenuation of low energy gammas
  - Must be light tight if using a scintillator detector – why ?

  – Beta detectors require thin entrance windows
  - Typically Al-mylar
  - But detection efficiency below 150 keV is difficult even with the thinnest window material

  – Alpha detectors require the thinnest of entrance windows
  - Typically Al-mylar < 1 mg/cm^2
  - Best possible approach is to not use an entrance window (eg. LSC or vacuum chamber)

Single channel gross counter

Ludlum 44-10 with 180-9 shielded sample holder

- **Manual operation**
- **NaI detector (2”x2”)**
- **Gross gamma counting**
- **2” planchet size**

- **Gamma background: ~ 400 cpm**

- **Sample holder:**
  - lined with 1.5” Pb
  - size: 10.5” x 18” (27 cm x 46 cm)
  - weight: 350lb (159 kg)

Part Number: 47-1591

Dual channel gross counters

Ludlum 2929 with 43-10-1

- Manual operation
- ZnS(Ag) + plastic dual scintillator (0.4 mg/cm^2 window)
- Alpha/beta counting
- 2” planchet size

- Alpha background: < 3 cpm
- Alpha efficiency: ^{239}Pu 37%

- Beta background: ~ 80 cpm
- Beta efficiency: ^{90}Sr/^{90}Y 26%, ^{99}Tc 27%, ^{14}C 5%

Dual channel gross counters

Protean MPC-1000-GFL

- Manual operation
- Windowless gas proportional counter (P10)
- Alpha/beta counting
- 2” planchet size
- 4” Pb shielding

- Alpha background: 0.05 cpm
- Alpha efficiency: ^{241}Am 23%

- Beta background: 0.7 cpm
- Beta efficiency: ^{90}Sr/^{90}Y 28%, ^{99}Tc 23%
- Beta-alpha and alpha-beta crosstalk < 0.1%

Dual channel gross counters

Berthold LB790

- Manual operation (10 samples)
- gas proportional counter (P10) with 0.21 mg/cm^2 window
- Alpha/beta counting
- 2” planchet size
- 4” Pb shielding (1200kg or 2640lb)

- Alpha background: <0.1 cpm
- Alpha efficiency: ^{241}Am 34%

- Beta background: 1 cpm
- Beta efficiency: ^{90}Sr/^{90}Y 50%
- Crosstalk: Beta->alpha <0.1% and alpha->beta < 1.0%

Dual channel gross counters

Mirion Series 5 XLB

- **Automatic operation (50 samples)**
  - Includes standard sources and background controls
- **Gas proportional counter (P10)**
- **Alpha/beta counting**
- **2” planchet size**
- **4” Pb shielding (324kg or 716lb)**

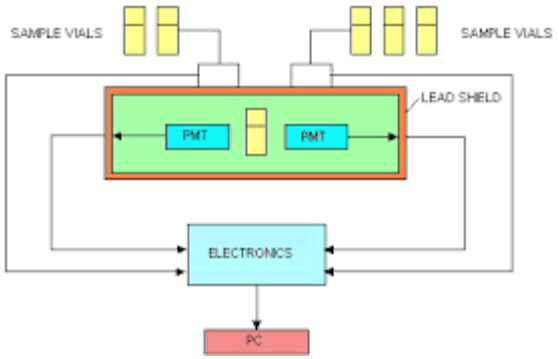
- **Alpha background: <0.1 cpm**
- **Alpha efficiency: ^{210}Po 38%**

- **Beta background: <0.75 cpm**
- **Beta efficiency: ^{90}Sr/^{90}Y 45%**
- **Crosstalk: Beta->alpha <0.1% and alpha-> < 1.0%**

Multichannel (spectroscopy) counting systems

Liquid Scintillation Counting (low energy beta and alpha analysis)

- **Samples dissolved in aqueous or organic solvent**
- **Aliquots added to scintillation cocktail**
  - typically 1ml of sample in 20ml vial
- **Vials counted sequentially in batch mode**
  - Includes standards and background samples
  - Protocols identify which isotopes to analyze
  - Dual PMTs (coincidence counting)

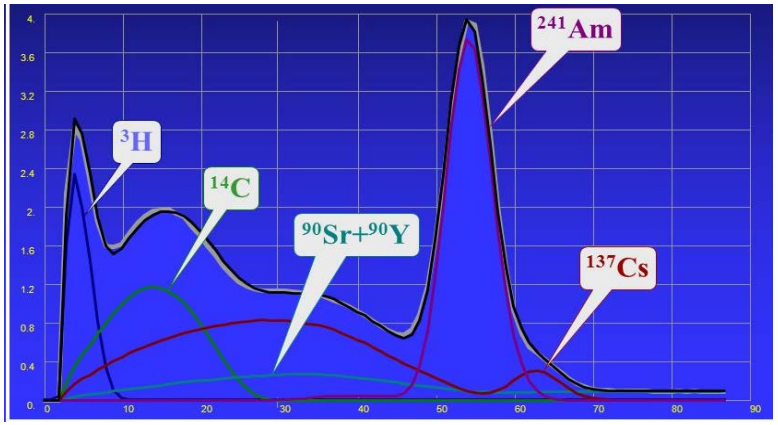


Quantulus 6220

Multichannel (spectroscopy) counting systems

Liquid Scintillation Counting (low energy beta and alpha analysis)

- **Vials are Pb shielded while being counted (i.e. low background environment)**
- **Pulse height spectra are analyzed on basis of spectral shape for the isotopes of interest**
- **Spectra are corrected for quench (chemical and colour)**
  - A built-in gamma source assists
- **Typical efficiencies:**
  - ^{3}H 60%
  - ^{14}C 95%

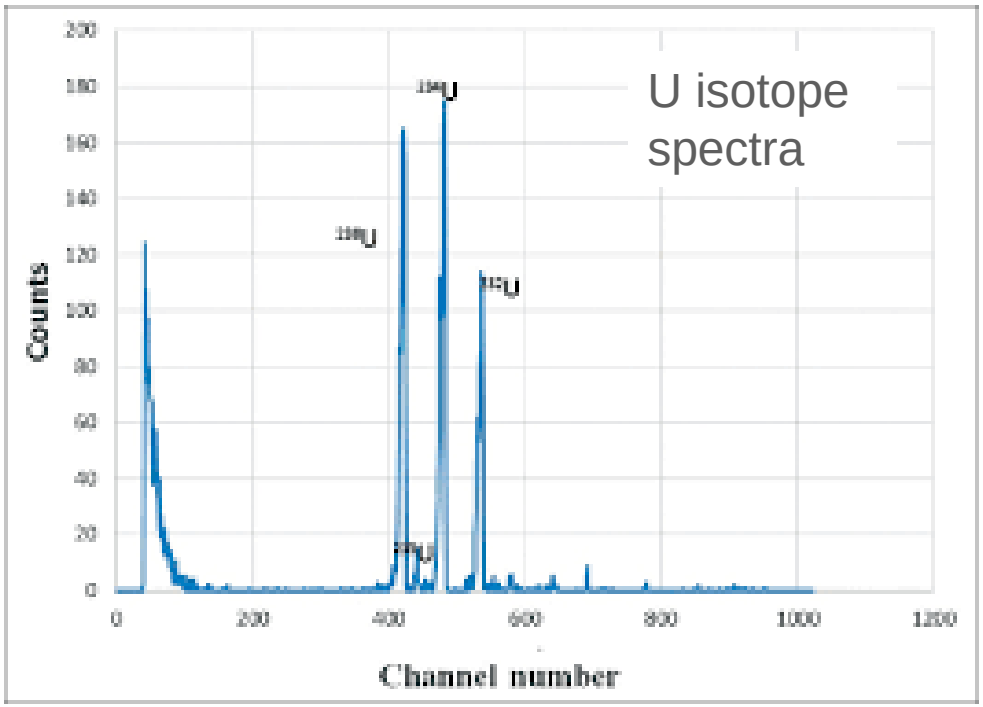


ORTEC Model 808 Vacuum chamber for alpha spectroscopy

- Housing dimensions: 21cm x 26 cm x 34cm
- Chamber dimensions: 11.4cm x 16cm x 16cm
- Weight: 9kg (20lb)
- Sample sizes up to 4”
  - typically require radiochemistry to give thin sources and best possible resolution
- Si detector
- Requires pump to evacuate chamber
- Analysis software package analyzes peaks

Alpha spectrometry

- Full width at half maximum (FWHM) resolution down to 20 keV (0.5% @ 4 MeV)



Multichannel (spectroscopy) counting systems

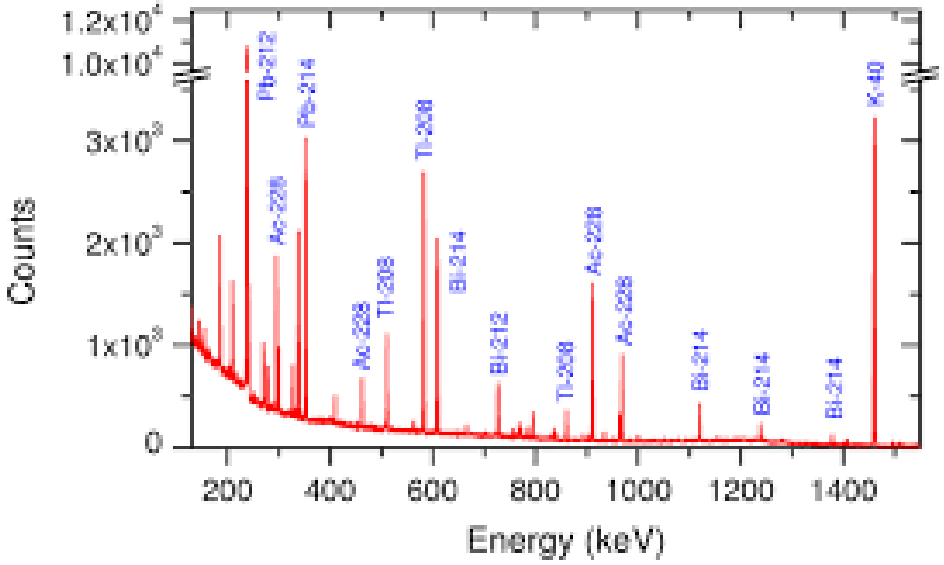
Gamma spectrometry

Model 737 Pb shield
4”Pb shielding with inner lining of tin and copper
950kg (2050 lbs)

Multichannel (spectroscopy) counting systems

Gamma spectrometry

Cu lining in low background shield



Spectrum of natural background (NORM) sample

Counting room equipment

Questions ?